Venus setting over Popocatepetl

Eclipse Maps and Observing Hints

Northern and Southern Star Charts

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor* HELEN S. FEDERER, *Managing Editor*

DECORATION VERSUS SCIENTIFIC REPRESENTATION

WHICH is more decorative, a map with New York on the Atlantic at the east side of the United States and San Francisco on the west, as we are accustomed to having it, or one "inside out" with New York west and San Francisco east? This is the nature of the comment by Orestes H. Caldwell, editor of **Electronic Industries**, in correspondence concerning the recent renovation of the famed constellation map on the ceiling of New York's Grand Central Terminal.

For some mysterious reason, ostensibly "decorative," the constellations had been represented in reverse, as if the artist had copied from the surface of a celestial globe, forgetting that the people in Grand Central would be looking up and out from the center of the vaulted heavens and not down from the outside.

Since the ceiling is a barrel vault rather than dome-shaped, a true-to-life portrayal of the heavens could not be achieved. The original designers (including an architect, a painter, and an astronomer) therefore decided that the decorative effect should be more important than scientific representation. "Hence," writes the present Assistant Terminal Manager, "the star map was installed in reverse." Moreover, "the ceiling in its present form has acquired an air of tradition which we feel is worth preserving."

It seems incredible that the reversion was intentional—more likely it was accidental. Geometric distortion in mapping curved surfaces on flat or differently curved surfaces is universal and unavoidable. Yet we gain much accurate information from such distorted representations, and at the distance between observer and ceiling in this mammoth terminal the distortion can hardly be noticeable regardless of the shape of the vault.

Few persons study the Grand Central ceiling for the purpose of learning the stellar configurations. The "wrong-way zodiac," as James C. Hickey, astronomical columnist of the New York **Sun**, has called it, serves only to confound and disappoint those star-minded persons

(*Continued on page 15*)

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CONTENTS

COVER: Venus setting behind the volcano Popocatepetl, seen across the valley of Cholula. This was a half-hour exposure on a night of full moon this January, taken from the porch of the bungalow of the Mexican National Astrophysical Observatory at Tonanzintla, Puebla. The gradual diminution in the density of Venus' trail is caused by the scattering of light (extinction) by the earth's atmosphere. Note the electric lights in the churches and in the distant farms. Photograph by Bart J. Bok. (See page 3.)

BACK COVER: NGC 4565, a large edge-on spiral in "the realm of the galaxies." This object, a most beautiful example of an edgewise spiral with a dark obscuring lane, is in Coma Berenices, 1945 co-ordinates, $12^h\ 33^m.7$, $+26°\ 17'.8$. Close examination of the photograph, which was taken with the Mount Wilson 60-inch reflector on March 6-7, 1910, with a five-hour exposure, will reveal many other galaxies in the field. Mount Wilson photograph.

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A general view of the observatory hill shows, from left to right (on the hill), the observers' bungalow, central administration and office building, housing of the 3-inch and 6-inch combination, the pump house, and the Schmidt dome. The white building at the foot of the hill covers the well used jointly by the town of Tonanzintla and the observatory. The pond is the town's supply of irrigation water.

TONANZINTLA REVISITED

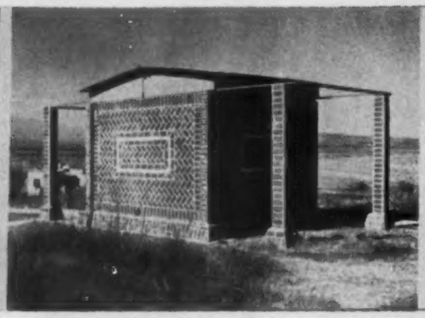
By BART J. BOK, *Harvard College Observatory*

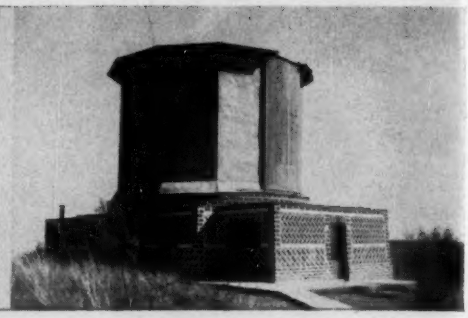
OLD-TIMERS among the subscribers to *Sky and Telescope* may recall an article in the December, 1941, issue on Mexico's new National Observatory at Tonanzintla in the state of Puebla. This was followed by two articles in the April, 1942, issue, one on the dedication of the new observatory and the other on the astrophysical congress held at that time. I had the good fortune to be invited by the Mexican Government to return to Tonanzintla for three months starting November 15, 1944. It may interest the readers of *Sky and Telescope* to see some photographs of the Mexican Astrophysical Observatory and surroundings, and to be brought up-to-date on its astronomical activities.

The front cover shows the valley of Cholula in moonlit grandeur. The observatory is located at an altitude of 7,500 feet on a hill near the village of Tonanzintla. From the observatory the two great volcanoes, Popocatepetl and Ixtaccihuatl, offer a magnificent and ever-changing spectacle. These mountains are about 25 miles away, but in the transparent atmosphere of the central plateau they are almost always seen clearly silhouetted against the sky. It is surprising how sharp are their contours on a fine summer night. One of the most exciting sights is to watch a 2nd- or 3rd-magnitude star "set" behind Popo. Through a pair of binoculars one sees the star literally snap out as it disappears behind the mountain.

The observatory is only eight miles from the city of Puebla and not more than three miles from a great tourist landmark, the seven-fold pyramid of Cholula. The view at the top of the page is taken from the road between

The observatory staff—from left to right are Juan Presno, librarian; Guillermo Haro; Graciela Gonzalez; Lazaro, one of the observatory caretakers; Joaquin Ancona Albertos; Director Luis Enrique Erro; Bernardo Castillo (face visible only), the observatory administrator; Octavio Cano; Guillermina Gonzalez; Augustin Prieto; Jose Alva, the observatory's mechanic; Paris Pishmish-Recillas; and Pedro, who is the other caretaker.





Some of the observatory buildings are shown above. On the left is the workshop where Sr. Alva holds forth. After the war, when machines are again available, there are plans to make this one of the most complete workshops at any observatory. In the center is the housing of the 3-inch Ross and 6-inch Brashear cameras, with a sliding roof; and the dome of the 26-31-inch Schmidt camera appears at the right. The brick covering is done in a mosaic style typical of Puebla. All pictures in this article were taken by the author.

Tonanzintla and the observatory. On the hilltop are the scattered buildings which together make the observatory. The central administration building, which has the offices, library, exhibition hall, and laboratory, is, of course, the largest of the buildings. Smaller buildings are the bungalow, which houses the bachelor members of the staff (the others live in Puebla and commute daily by bus), the large workshop, the photographic building with the darkrooms, and the housings of the various telescopes. The mosaic-brick covering of most of the buildings lends a characteristic "Poblano" charm to the architecture.

The staff of the observatory has grown considerably since 1941-42. At the time I took the staff photograph reproduced with this article, four of the members were absent. The assistant director, Dr. Carlos Graef, was at Harvard as a Visiting Professor of Mathematics. Professor Luis Rivera Terrazas was at the time working as an observing assistant at the Yerkes Observatory. Finally, Manuel Guarnero, the technician in charge of the darkrooms, and Sr. Lauro, the night assistant, were asleep after a good night's work.

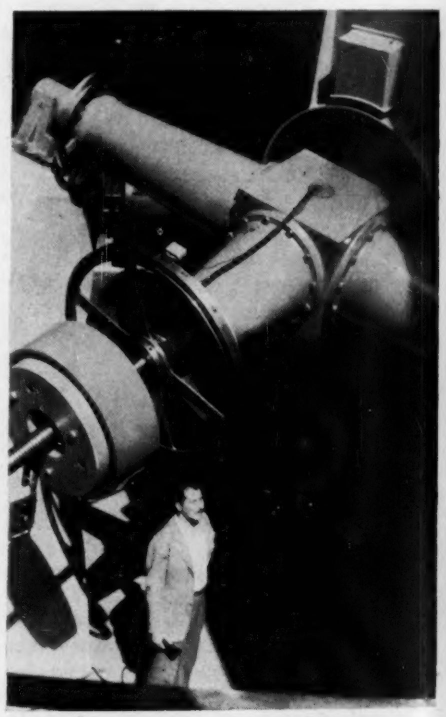
The 3-inch Ross and 6-inch Brashear cameras are on a Zeiss mounting, which was originally a part of the equipment of Director Erro's private observatory. Beside the camera stands the night assistant, Sr. Lauro.

The program of the observatory is mostly photographic, the principal instruments being a 3-inch Ross camera and 6-inch Brashear camera on the same mounting, and the 26-31-inch Schmidt. When I was in Mexico, the Schmidt was still going through some final tests and adjustments. There had been considerable delay in the completion of the drive, because of the presence of voltage fluctuations in the current. These difficulties were overcome with the aid of an electronic drive, designed and constructed by Ing. Eduardo Diaz, of the Polytechnical Institute in Mexico City.

During my visit, the 3-inch Ross camera was used extensively in various problems in the fields of astronomical photometry and the structure of the Milky Way. Octavio Cano, one of the younger staff members, was busy taking six-hour runs to measure the atmospheric extinction at the zenith for blue, red, and yellow light. That this extinction is still appreciable, in spite of the great altitude of the central plateau, can be noted on the cover picture; the trail of Venus is very much less dense near the horizon than higher up in the sky. Cano's preliminary results indicate that for a star at the zenith the extinction in blue light is three tenths of a magnitude and for yellow light two tenths of a magnitude.

Graciela Gonzalez and Augustin Prieto were working on the star counts for the southern Milky Way in Puppis and Vela, the section on which the Mexican investigators plan to concentrate for the next few years. As a result of their counts they were able to delineate and study several extended dark nebulae. The Milky Way in Puppis and Vela is relatively free of local, irregular obscuration; the dark nebulae that have been found appear to be at distances of more than 1,500 light-years from the sun.

Interesting and rather unexpected results were obtained from a study of star colors of some high-temperature *B* stars in the Puppis and Vela section. Ing. Joaquin Ancona Albertos, the former rector of the University of Yucatan, the author of a textbook



The 26-31-inch Schmidt camera, with Sr. Haro holding the block with the control buttons. Besides the polar axis (note the small tilt at 19° north latitude), the picture shows the declination axis and circle.

on cosmography, and now a member of the observatory staff, could show from his work on colors in the Puppis region of the Milky Way that even in the apparently unobscured parts there is considerable reddening of starlight by smoothly distributed interstellar dust. Ancona's preliminary results, supported in part by colors measured by Guillermina Gonzalez, indicate that, overlying the smooth and apparently unobscured parts of the Puppis region, there is a veil absorbing two to three tenths of a magnitude per thousand light-years.

When I left Tonanzintla in the middle of February, the work on the Puppis-Vela region was still in full swing. There were plans to extend the work on star counts to fainter magnitudes with the Schmidt camera, and color work had been mapped out for several additional fields in the same part of the sky. The Mexican astronomers are expecting a field day when, next summer, they will apply their techniques of color measurement to the central star clouds in Sagittarius, which at the latitude of Tonanzintla (19° north) reach a maximum altitude of about 40 degrees when on the meridian.

The work of Dr. Paris Pishmish-Recillas, formerly of Istanbul and of Harvard Observatory, is quite diversified. She has just completed a study of the rotation of the galaxy and the K-effect and she had under way two studies of galactic clusters, one on the color-magnitude distribution in the cluster Messier 67, the other on the motions of stars in the double cluster h and Chi Persei. With that, and with two lovely children to take care of, she is a busy lady.

In the beautiful church of Santa Maria de Tonanzintla, one finds a remarkable and colorful mixture of Indian and Christian sculpture.

In the absence of Dr. Graef, Guillermo Haro is Director Erro's chief assistant and trouble shooter. Haro is in charge of the night work, and has it organized in a model fashion. The testing and adjustment of the Schmidt are also in his hands. For 15 months in 1943-44, Haro worked at the Oak Ridge station of Harvard Observatory. He came back to Mexico with plans to work on the colors of the stars, his special interests being at opposite ends of the spectral sequence, the blue-white *B* stars and the very red *R* and *N* stars. Haro has the results of an investigation on the Milky Way in Hercules and Vulpecula about ready for publication.

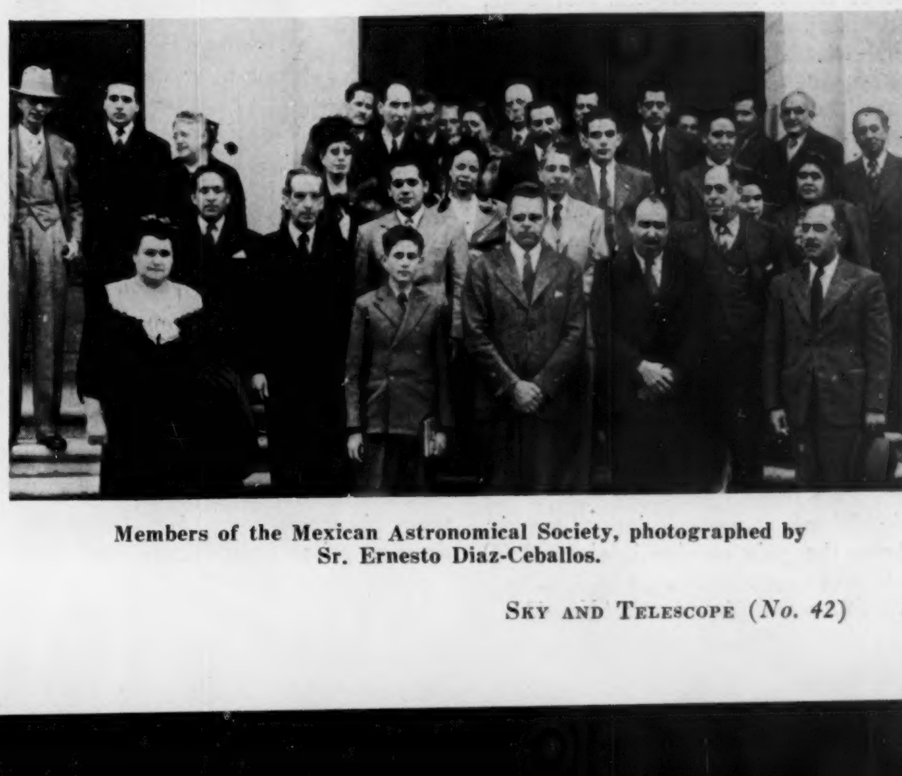
The observatory at Tonanzintla is well worth a visit by any interested amateur astronomer from the United States who happens to be down Mexico-way. For scenery, there is no place in Mexico from which Popo and Ixta can be seen any better. The region of Tonanzintla and Cholula is one of the richest in archeological gems and beautiful churches, one of the finest (at left) being within walking distance of the observatory in Tonanzintla. The observatory itself is an active one, and the casual visitor will always be rewarded by hearing of some new and interesting research on the southern skies.

Sociedad Astronomica de Mexico

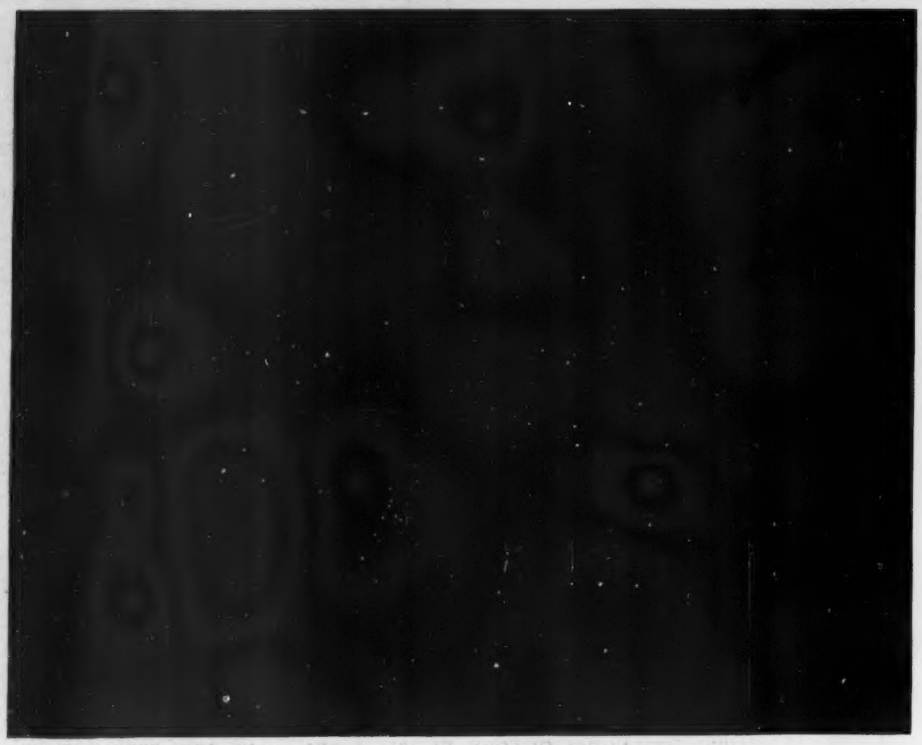
THE photograph shows the members of the Mexican Astronomical Society. It was taken on the steps of the observatory at Tacubaya on February 5th of this year. In the front row on the right (holding his hat) is Luis Enrique Erro, the director of the Astrophysical Observatory at Tonanzintla. Beside and slightly behind him is Joaquin Gallo, director of the observatory at Tacubaya. Then follow Domingo Taboada, the newly elected president of the Mexican Astronomical Society and the owner of Mexico's finest amateur observatory, and Bart J. Bok, of Harvard, who addressed the February meeting. The young man beside him is Enrique Maupomé, whose father, Augustin Maupomé (in the dark suit) was the retiring president. The elder Maupomé is Mexico's leading variable star observer; the young son has helped his father in this work.

Shortly after this meeting it was announced that the Mexican Astronomical Society will soon have a home of its own in Mexico City. After a visit by Srs. Taboada, Gallo, and Erro, the municipal president of Mexico City, Lic. Rojo Gomez, announced that the city will provide the Mexican amateurs with the grounds and building for a people's observatory. The tentative plans include a housing for the society's reflector, a laboratory for optical work, and a lecture and exhibition hall with a seating capacity of 100 or more. Sr. Maupomé will probably be in charge of the program of the new observatory.

BART J. BOK



Members of the Mexican Astronomical Society, photographed by Sr. Ernesto Diaz-Ceballos.



A patrol-camera photograph of a portion of the spring sky. The Big Dipper is at the top, Canes and Coma in the center, Leo is in the lower right, and Arcturus at the extreme left edge. The images at the edges of the wide field show considerable distortion. Harvard Observatory photograph.

THE STARS OF SPRING

By MARIAN LOCKWOOD

When the Milky Way does its semiannual turnover, less brilliant but famous star groups occupy the heavens overhead on a warm spring night, as told here and in the Hayden Planetarium this month.

IN the spring the Big Dipper, which can be regarded almost as the keystone of the northern arch of the heavens, is in a most advantageous position for observation. About the 1st of April, at 9:00 p.m. war time, this familiar group of stars is seen climbing up the northeastern sky, already much more than half its way from the horizon to a point above the pole star. By the middle of May, the early hours of the night find it high above the pole. Late in spring and early in summer, the Dipper is observed slipping down the sky to the west of the pole.

These changes of position from night to night result from the sun's slow apparent journey eastward around the sky once a year. Any star reaches a given point in the sky four minutes earlier tomorrow night than it does tonight. This means a monthly difference of two hours, or that if the Big Dipper appears almost exactly above the pole on April 5th at 1:00 a.m., it will reach the same position on May 5th at 11:00 p.m.

The Big Dipper is of particular value as an excellent guide to other stars or groups of stars, especially when it is high in the sky at this season of the year. For instance, beneath the curve of the Dipper's handle is the constellation Canes Venatici, which legitimately can be called a spring constellation for it is in a conspicuous position during this season. Although Canes Venatici is composed mostly of faint stars, and is often neglected in favor of the larger and better-known groups, it has an interesting history.

The brightest star in Canes is of the 3rd magnitude and is known as Cor Caroli, a name which means the heart of Charles. Halley is reputed to have named it in 1725, after Charles II of England. Cor Caroli, which is a fine double star for amateur observers, can be found by drawing a line from Dubhe, the upper one of the two pointers at the outside of the Dipper's bowl, through Phecda, diagonally across the bowl from Dubhe, and continuing the line almost twice that distance farther.

Canes Venatici is Latin for the Hunting Dogs. These are supposed to be the dogs driven by the Herdsman or the Bear-driver, Bootes. (Arcturus, the bright star in Bootes, can be found by continuing the curve of the Dipper's handle away from the bowl.) Canes is a modern star group, however, invented by Hevelius. The dogs' names are Asterion and Chara; the latter contains Cor Caroli as well as Chara, which is the name sometimes used for the second brightest star, designated as Beta in the constellation. These two stars form an almost straight line with Arcturus. Cor Caroli comes to the meridian about 10:00 p.m. war time, on May 20th. It forms with Spica, Arcturus, and Denebola a perfect diamond, known as the diamond of Virgo.

In Canes is located the superbly beautiful galaxy known as the Whirlpool nebula, M51. While it cannot be seen in any detail without a powerful telescope, you can enjoy its great beauty by studying modern photographs of it. It is less than five degrees from Alkaid in the direction of Cor Caroli.

Now, beneath the stars of the Hunting Dogs are those of Coma Berenices—Berenice's Hair. This is a most beautiful group. It is a real star cluster which greets the discerning eye as a cascade of loveliness against the blue of the night sky. The group lies almost wholly within the triangle formed by Denebola, Arcturus, and Cor Caroli.

The story of Coma Berenices is that of a great queen of ancient Egypt. According to the legend, Berenice, a lady of unsurpassed beauty, was married to Euergetes, one of the kings of Egypt. When it became necessary for the king to depart upon a particularly dangerous and warlike expedition, Queen Berenice vowed to the gods that if he could be safely returned to her arms, she would sacrifice her beautiful hair and place her precious tresses upon the altar in the temple of Venus. When her husband returned from his expedition victorious, Berenice fulfilled her vow. During the night the sacrifice was stolen from the altar, removed, no doubt, by the meanest of thieves. The astronomer royal was, however, quite equal to the occasion. He escorted the king and his consort to the terrace of the temple, where he showed them in the sky the beautiful clustered stars of which we are speaking. Those, he

explained, were the tresses of Queen Berenice, transported by Venus into the sky as an everlasting memorial to the great sacrifice and beauty of the queen. And Queen Berenice, so the story goes, was entirely satisfied.

It was not until 1602, when Tycho Brahe gave it a definite place among the constellations, that Coma Berenices gained a settled position in the sky. Since then it has held its own among the constellation figures. Perhaps no words can more graphically describe this group than those of that incomparable teacher and writer, Garrett P. Serviss. Of Coma he says, it has a "curious twinkling, as if gossamers spangled with dewdrops were entangled there. One might think that the old woman of the nursery rhyme who went to sweep the cobwebs out of the sky had skipped this corner, or else that its delicate beauty had preserved it even from her housewifely instinct."

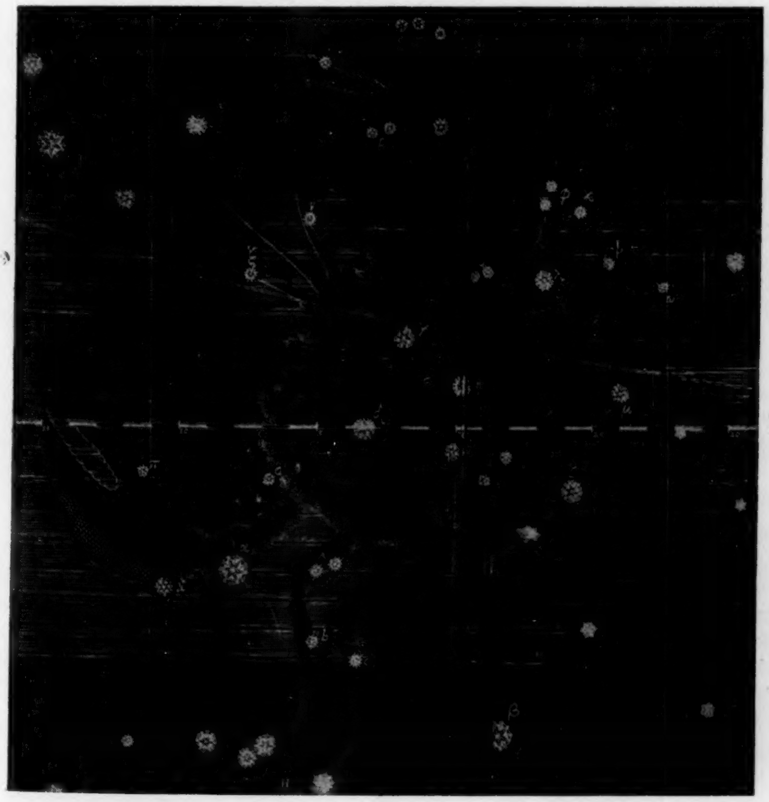
The Coma star cluster comes to the meridian about 10:00 p.m., the middle of May. It is one of the nearest galactic clusters, about 263 light-years away. Coma contains the north galactic pole, so that the comparative lack of bright stars in this part of the sky is more than made up by an abundance of galaxies. There are also several fine globular clusters in the region, such as M3 and M53.

It should be noticed that for stargazers in mid-northern latitudes the early part of April is a time of rich reward in the sky. If you pick the right hour of the night, let's say about 9 o'clock in the middle of April, or 10 o'clock at the end of March, you will find Rigel just about to disappear over the southwestern horizon. Visible also at this time will be Betelgeuse, Aldebaran, Capella, Sirius, Castor, Pollux, Procyon, Regulus, Arcturus, and, just about to come up in the east, Vega and Spica. This is truly a gorgeous time of year, for more of the brilliant stars can be seen now than at any other season. With Coma overhead, the Milky Way extends nearly all the way around the horizon.

Located in the zodiac between Gemini and Leo is the constellation Cancer, composed of faint stars. According to the historian Macrobius, the name Cancer, meaning Crab, was chosen by the Chaldean astronomers because it typified so well the sun's apparent backward or southward movement at the summer solstice. In former times when the sun reached the solstice, its greatest declination north, it was located in this constellation and was directly overhead for those people who lived along the parallel of latitude which we today call the Tropic of Cancer. It is impossible for the sun to be in the zenith of any person living north of this imaginary line.

According to an old Greek legend concerning this constellation, Juno became jealous of the great fame of Hercules, and while the hero was struggling with the Lernaean monster she tried to destroy him through the evil offices of the crab. Hercules instead, however, put an end to the crab. Juno finally persuaded Jupiter to place the crab among the stars as compensation for its sacrifice.

The star cluster in Coma Berenices, as photographed by Harvard's 8-inch Ross-Lundin camera; exposure 60 minutes. Gamma (15) Comae is at the top center; 23 Comae is near the lower left edge. Further identification can be made from Norton's "Star Atlas."



Cancer, the Crab, as pictured in Bayer's famous "Uranometria."

The most interesting and conspicuous feature of Cancer is the star cluster known as Praesepe, the Manger. The two faint stars, one on either side of the Manger, known as Asellus Australis and Asellus Borealis, represent the two asses which played a part in another story concerning this historic constellation. Praesepe is sometimes also known as the Beehive, because of the large number of stars contained therein. Although the constellation of Cancer is among the most inconspicuous in the entire sky, and certainly among those in the zodiac, it can still be identified by the faint patch of light which is Praesepe. Remember, in looking for something as faint as this object, to glance at it out of the corner of your eye, for we see faint objects in dim light more easily with the outer parts of the ret-

ma. If you could observe Praesepe through a good-sized telescope, you would discover that there are some 358 stars down to the 18th magnitude, with about 80 brighter than 10th magnitude. The cluster is 500 light-years distant. The bright central portion of the Beehive is about 10 light-years in diameter, or approximately 60 trillion miles across.

Now it may occur to you at this point that the constellations mentioned so far are the more inconspicuous ones of spring. That is quite true. Almost all stargazers know Leo, and how to find it, by drawing a line through the pointers of the Big Dipper, from Dubhe through Merak, and about as far away from the Dipper as Polaris is located in the opposite direction. Leo is composed of two asterisms, a sickle and a right-angle triangle.

By drawing a line from Gamma Leonis, the brightest star in the blade of Leo's sickle, southward through Regulus, and continuing it about twice that distance, the observer will discover Alphard, the brightest star in Hydra, the Water Snake. The head of the snake can be found just below Praesepe, and consists of an interesting formation of five faint stars of about equal brilliance. The body of the snake extends eastward for over 90 degrees—it is one of the largest constellations in the sky. According to Aratos,

But lo! afar another constellation,
They call it Hydra. Like a living creature
'Tis long drawn out. His head moves on below
The midst of the Crab; his length below the Lion:
His tail hangs o'er the Centaur's self.

This constellation is supposed to represent the Lernaean monster with which Hercules fought when Juno sent the crab to attack him. Hydra was said to have many heads, none of which could be permanently destroyed. When one was cut off, another grew immediately to take its place. Hercules finally destroyed all but one, the central head, which was said to be immortal, and this he successfully buried beneath a rock.

East of Alphard and south of Regulus, the careful observer can find the constellation Sextans, the Sextant, which is entirely composed of stars of 4th magnitude or fainter.

On the back of Hydra are two other figures, Corvus, the Crow, and Crater, the Cup. The three constellations are associated in legend. Corvus is often called "the spanker," after a certain type of sail which it resembles. Its top stars point directly to Spica. In southern latitudes the observer, by bisecting Corvus vertically, will be led to the top of Crux, the Southern Cross.

Crater, the Cup, is very clear once you pick out the stars forming it. It is about 15 degrees to the west of Corvus, and due south of Denebola. Six 4th-magnitude stars form the cup and are, as would be expected, in the form of a semicircle.

And so, as our winter friends—Taurus, Orion, and Canis Major, with their neighbors—pass into the west in the twilight glow of a spring evening, the familiar constellations of spring return, enhancing with their beauty the calm loveliness of an April night.

ASTRONOMICAL ANECDOTES

WAR-TORN OBSERVATORIES

IN this department, several months ago, there was a mention of the destruction of the Poulkovo Observatory. Now there has come to my hand a note from Professor W. L. Kennon, head of astronomy and physics at the University of Mississippi, to the effect that there is a reproduction of the building in our country. His note reads: "You may be interested to know that the Old Observatory building now standing at the University of Mississippi is an exact replica on apparently a somewhat smaller scale of the original building of the famous Poulkovo Observatory. The building here was erected in 1859, and was to have housed the Dearborn telescope which was built by Alvan Clark to the order of the University of Mississippi but which was never delivered because of the Civil War. Because the building at Poulkovo was destroyed by enemy action, it would seem to give our old building an added historic interest."

Indeed it does, but word now comes that much of the building at Poulkovo is to be rebuilt in its original form.

The editor of *Etude*, the magazine known to all musicians and most students of music, had in his October, 1944, issue an interesting essay on the music of the spheres. He discussed the musician-astronomers of the past. After the article was in print, I learned that Albert Coates, a distinguished modern conductor of great symphony orchestras, studied astronomy at the Poulkovo Observatory.

Other Russian observatories suffered the fury of German hate and plunder lust. At Simeis, two astrographic objectives were evacuated with the retreating Russians in 1942. In September and October of 1943, the Germans shipped away 30 truckloads of equipment, including the 40-inch reflector, the mounting of the double astrograph, another astrograph, a photoheliograph, three stellar spectrographs, a large coelostat, several fine measuring engines, and two astronomical clocks. All the photographs taken with the instruments, and all the laboratory equipment, likewise were stolen and shipped to Germany. Parts of the buildings were destroyed, the rest was used as barracks and a stable. In January, 1944, the main building at Simeis caught fire and burned for two days; the Germans made no effort to save it. The account closes with these words: "The Germans may say that Poulkovo was in the battle area and that its destruction was unavoidable; at Simeis, however, the only shots fired in the vicinity of the observatory were those of firing squads executing civilians."

Doubtless we shall learn that almost every observatory in occupied territory, not only in Russia but in other countries as well, was looted and largely destroyed. The 40-inch reflector of the Royal Observatory at Uccle, Belgium, was also stolen by the Germans. It is very likely that in their blind worship of the name Zeiss they have tried to carry back to the country of origin the instruments made by that firm; but maybe they want to compare a good British reflector (the one at Simeis) with a bad German one (from Uccle)!

The meridian circle at Uccle was carried away to Leipzig, where the observatory was wiped out by Allied bombings.

There is talk of reparations payments "in kind" by the Germans. I can think of nothing better than that the Zeiss firm should be kept out of mischief for a generation or so, building instruments to replace and to supplement those of European observatories. Doubtless there are thousands of laboratory instruments beneath the rubble of French, Russian, Belgian, Dutch, Polish, and British university buildings that could be replaced by Zeiss, at the expense of the German people. The designs should be American and British and French, however, and not German; there are many large Zeiss telescopes in Europe and Asia from which no reports of research ever come because, at least in some instances, the instruments have been designed to suit the engineers and not the astronomers.

R.K.M.

NEWS NOTES

By Dorrit Hoffleit

A WELL-OBSERVED VARIABLE STAR

W Lyrae is a variable star that has been almost continuously observed since 1896. Leon Campbell, recorder of the American Association of Variable Star Observers, has compiled all the available observations in order to analyze the constancy of the star's period of light fluctuation. The average period for the 48-year interval of the observations is 196.6 days. Mr. Campbell finds that "the mean period apparently decreased from 198 days in the early 1900's to 193 days in 1925, and then gradually increased to 199 days in recent years." The beautiful compilation of observations and light curves on this star should constitute meaty data for the theoretical worker who would account for stellar variation.

ICE ON THE MOON?

Last summer, H. Percy Wilkins sent to the British Astronomical Association a drawing he had made of the lunar walled plain, Plato, which he believed exhibited an unusual appearance. The floor of the "amphitheater" looked exceptionally dark, while the northern rim, usually as visible as the southern, was "clearly noted to be razed to the surrounding level." Wilkins suggested that a dark cloud or vapor might account for the unusual aspect.

The drawing and comment incited lively discussion at the September meeting, for which minutes have recently been published in the *Journal* of the B.A.A. Mist on the moon implies an atmosphere, while the consensus of modern opinion refuses to allow an appreciable amount of gas above the lunar surface.

The discussion at the meeting then took an unusual turn, for F. J. Sellers stated that the possibility of a mist that might quickly disperse should not be entirely disregarded. A theory of glaciation of the lunar surface, ruled out long ago on the basis of bolometric measurements (Coblentz and Lampland), deserves reconsideration, he believes. The bolometric measures may conceivably have represented not only the reflected heat from the moon, but some radiated heat as well. In that case, the temperature on the bright side of the moon might actually be much lower than the accepted values.

If the moon were covered with thick ice, its surface temperature, even at lunar noon, might never reach 0° centigrade, whereas rock surfaces would certainly reach at least 100°. Sellers offered arguments why such an assumption of a cold moon cannot, on the basis of existing observations, be completely ruled out. New critical observational data on the moon's surface temperature are evidently desirable.

WHITE DWARF TWINS

Seventy white dwarfs have been discovered to date. In 11 cases, a white dwarf has been found as one component in a binary system. Until Dr. W. J. Luyten's recent discovery, however, no twin white dwarfs were known. The twins are in Antlia, about 50 degrees south of Regulus. They are of 14th magnitude, nearly identical in color, and apparently in every way genuine members of the famous dwarf species.

Originally, a wide double star had been announced, with a separation of nine seconds of arc. Upon examining the star with the 36-inch Steward Observatory reflector, in the course of his systematic search for white dwarfs, Dr. Luyten later found that the fainter component of the wide pair was simply an optical companion. The brighter component, however, appeared elongated. Verification of this star's double character was obtained from Mount Wilson, where Dr. Walter Baade obtained a photograph with the 100-inch which revealed two stars separated by three seconds of arc and differing by only 3/10 magnitude. Both components were found to be white dwarfs.

Although insufficient data are available for the complete determination of their relative orbit and other characteristics, it is estimated that their period of revolution is of the order of 250 years. This quantity should become determinable within 10 years. Probably the twins are each intrinsically 1,600 times less luminous than the sun, and have diameters smaller than the earth's. If their masses are typical for such stars (about the mass of the sun), they have densities of about 25 tons per cubic inch.

LIGHT—WHAT IS IT?

A short while ago *Time* and several newspapers carried items on a discovery by Dr. Felix Ehrenhaft, formerly of Vienna, from which he concluded that light "is some kind of electrodynamic force which travels not in waves or in straight lines, but like a corkscrew." Dr. Ehrenhaft projected a very narrow beam of light vertically in a glass tube. When he dropped microscopic particles into the beam, the ones smaller than the wave length of light fell vertically, as expected; but those longer than the wave length of light spiraled down the tube. The energy causing the rotational motion, the physicist believes, could have been provided only by the light: "just as matter rotates light, so light rotates matter."

A recently received copy of *Southern Stars* (New Zealand Astronomical Society) for August-September, 1944, discusses another theory of radiation, one by the late Sir Shah Sulaiman, which he gave in his presidential address before the National Academy of Sciences of India on February 22, 1941. Seeking on the basis of newer knowledge to bring nearer to solution the age-old controversy between Newtonian corpuscular theory and the wave theory, Sulaiman summarized as follows:

"The obvious solution of the problem is that light is a binary corpuscle, consisting of one positive and one negative charge rotating periodically round each other, under their mutual force of attraction, the whole moving forward with high velocity.

"This fully explains the dual aspect of light, reconciling all the known phenomena. This Rotational or Binary theory can also account for an inherent loss of energy with time, doing away with the supposed recession of the nebulae. Similarly, atoms and molecules show maximum and minimum effects, and so would an electron if considered as a rotating magnet. All this restores reality to Nature."

FRANKLIN MEDAL AWARD

The Franklin Institute of the State of Pennsylvania, in Philadelphia, announces the award of the Franklin medal to Dr. Harlow Shapley, "In consideration of his many valuable contributions to the science of astronomy, and especially of his work in the measurement of the vast distances necessary for the determination of the nature and extent of our galaxy, as well as those of other galaxies external to ours."

Other Franklin medalists include Albert Einstein, H. A. Lorentz, A. H. Compton, A. A. Michelson, G. E. Hale, Sir James Jeans, H. N. Russell, Robert Millikan, Max Planck, G. W. Pierce, and Charles A. Parsons.

The actual awarding of the medal takes place on April 18th, at the annual Medal Day exercises in Philadelphia.

Amateur Astronomers

THIS MONTH'S LECTURES

Boston: On Thursday evening, April 12th, Charles A. Federer, Jr., of Harvard College Observatory, will speak to the Amateur Telescope Makers of Boston, at the observatory in Cambridge. His topic will be "Observational Methods — Old and New."

Chicago: At the Tuesday, April 10th, meeting of the Burnham Astronomical Society a debate will be held, with three members upholding the meteoric impact theory and three the volcanic theory of the origin of lunar craters. There will also be discussion of the April evening sky, and special reports on observations and occultations. The meeting is held in the Chicago Academy of Sciences auditorium.

Cincinnati: On Friday, April 13th, Dr. Frank K. Edmondson, of Indiana University, will speak to the Cincinnati Astronomical Association on "The Measurement of Stellar Velocities." Kodachrome slides of McDonald Observatory, where Dr. Edmondson did some of his recent work, will be shown. The meeting is at 8 o'clock at the Cincinnati Observatory.

Cleveland: "The Revelations of the Spectroscope" will be the topic of a lecture before the Cleveland Astronomical Society on April 6th, Friday. Dr. C. K. Seyfert, of Warner and Swasey Observatory, is the speaker. The society meets at 8:00 p.m. at the Warner and Swasey Observatory.

Detroit: At the meeting of the Detroit Astronomical Society on Sunday, April 8th, Miss Elisabeth Achelis, president of the World Calendar Association, will speak on "The Proposed World Calendar." The meeting is at 3:00 p.m., at Wayne University.

Indianapolis: Members of the Indiana Astronomical Society will hear a talk on Saturn, by Walter Wilkins, at their meeting on Sunday, April 8th. This group meets at Odeon Hall.

Madison: "Life on Other Worlds" will be discussed by Dr. J. H. Gieselman at the April 11th meeting of the Madison Astronomical Society, at Washburn Observatory.

New Haven: Mary Warren, past president of the society, will address the New Haven Amateur Astronomical Association on "Stars with Extended Atmospheres," at the meeting of that group at Yale University Observatory on April 21st, Saturday evening.

New York: "Cosmic Rays," by Dr. Serge A. Korff, New York University, will be this month's lecture before the Amateur Astronomers Association. The meeting is on Wednesday, April 4th, 8:00 p.m., in the Roosevelt Memorial building of the American Museum of Natural History.

Washington, D. C.: At the meeting of the National Capital Amateur Astronomers Association on Saturday, April 7th, Frank Neumann, chief of the Section of Seismology, U. S. Coast and Geodetic Survey, will speak on "The Seismicity of the Earth."

Worcester: Leon Campbell, of Harvard College Observatory, will speak to the Aldrich Astronomy Club on Tuesday, April 10th. His topic is "Under Southern Skies."

CLEVELAND PUBLIC NIGHTS

"Stars that Vary in Brightness" will be the lecture topic at the open nights at Warner and Swasey Observatory, April 26th and 27th. Observation with the telescope will follow the lecture. Reservations may be had by calling the Case School of Applied Science, GArfield 6680.

CHAMBERLIN OBSERVATORY IN DENVER

The 1945 *Bulletin* of Chamberlin Observatory of the University of Denver contains complete information on the present and past activities of this institution. The principal instrument is a 20-inch refractor which has completed its 50th year of operation. The only research project which is being continued during the war is the computation of the motion of the periodic Comet d'Arrest. This was computed from the comet's previously observed appearance in 1924, through three complete revolutions, to 1943. As a result of this work, the comet was found in October, 1943, within 1.2 days' motion of its true place. Reconciliation of the old and new observations is now being made.

An important contribution to Denver's opportunities for public education is the regular program of visitors' evenings presented by the Chamberlin Observatory, which is open to the public during 1945 for two hours every Wednesday evening. An illustrated lecture and tour of the observatory features every program, while each month special objects are selected and announced in advance for observation with the 20-inch refractor.

Reservations for visitors' nights may be made by phoning the director of the observatory, Albert W. Recht, PEarl 8797, but special groups, such as clubs and high school classes, should not come on public evenings but make special arrangements with the director.

AUTOMATIC DEAD-RECKONING NAVIGATOR

On February 15th announcement was made of the use on B-29 Superfortresses and other planes of a device which gives the navigator continuous readings of dead-reckoning latitude and longitude. In its present state, the instrument does not include correction for drift, which the navigator must himself compute, and it is also still advisable for him to check his position with occasional celestial sights.

The new development has been made by the Eclipse-Pioneer division of the Bendix Aviation Corporation, with the co-operation of the Air Technical Service Command at Wright Field and the Navy Department. From the dial of the instrument longitude and latitude are read off directly, as well as the air miles flown and the compass heading of the plane. Eclipse-Pioneer has previously helped the aerial navigator with the Gyro Flux Gate compass, described in *Sky and Telescope*, January, 1944.

The new instrument, known as the API, must be set by the navigator to his starting position and the proper magnetic variation. By a system of friction drives, cylinders, and disks, the device applies air speed and compass heading to this original position, requiring only a fraction of a second to respond to each change in the craft's heading or speed. Perhaps its most remarkable achievement is in taking into account the curvature of the earth, whereby the meridians of longitude converge as the pole is approached, so that departure distances are automatically changed to differences of longitude.

NAMES OF PLANES

Through Science Service we learn that the first jet-propelled plane to be used by the United Nations in action against the enemy is the *Gloster Meteor*, a British plane. It was used in France against the Germans last summer. As many know, our own jet-propelled plane, the P-80, has been named *Shooting Star*.

Eclipse Maps and Observing Hints

By Isabel M. Lewis

Communication by the Superintendent, U. S. Naval Observatory

THE coming total eclipse of the sun will be observable in its partial phases over nearly all of North America, the north polar regions, the North Atlantic Ocean, Europe, the north coast of Africa, and western and northwestern Asia.

In addition to the data and maps published in the supplement to the 1945 *American Ephemeris* on the subject of this eclipse, two pamphlets have been published abroad by H. O. Gronstrand giving predictions and maps for Scandinavia and Finland.

In Mexico and all of the southwestern and western parts of the United States, the western part of Canada, and part of Alaska, the sun will rise more or less eclipsed. Along the line marking the southern limit of the eclipse (see map, *Sky and Telescope,* March, 1945, page 4), there will be only a grazing contact of sun and moon and no eclipse will be seen. From this line northward to the path of totality, an increasingly greater partial eclipse will be observed. The magnitude of the greatest obscuration for any place in the eclipse area shown on the map reproduced below may be estimated by means of lines roughly paralleling the southern limit of eclipse and the path of total eclipse. On these lines are indicated the decimal part of the sun's *diameter* covered by the moon at the time of greatest obscuration, which is not quite the same as the *area* of the disk obscured.

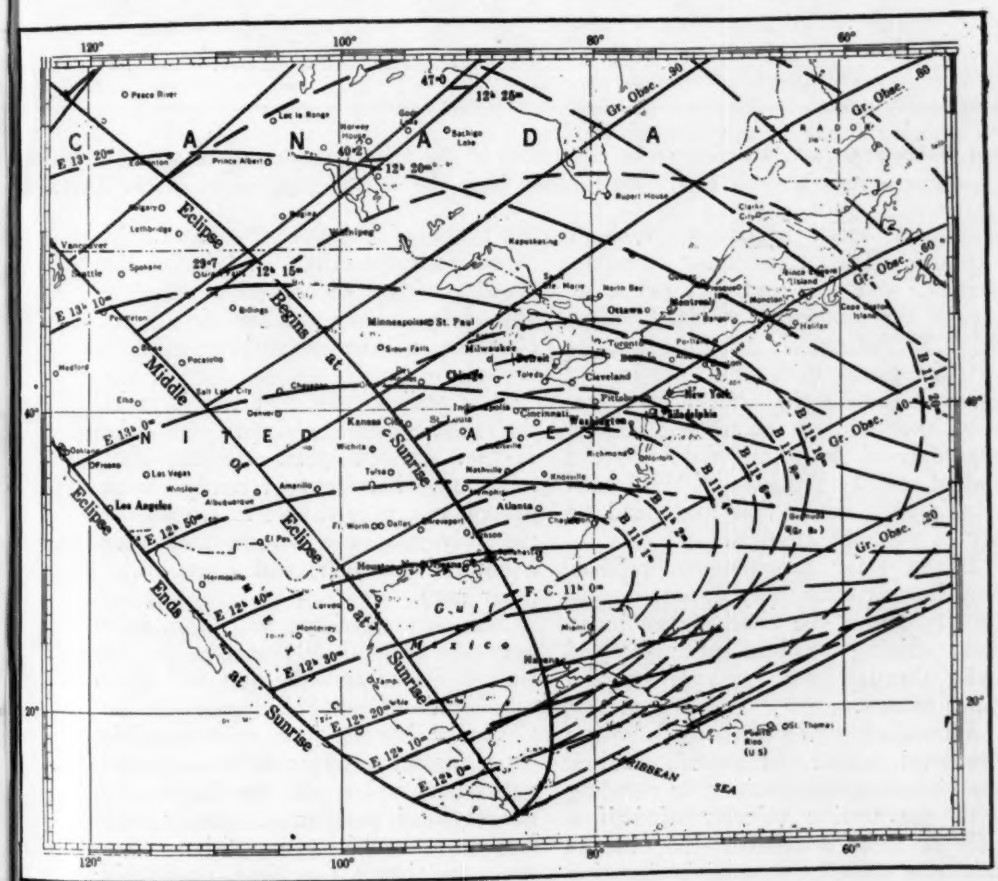
By means of the curves marked B or E followed by the Greenwich civil time, one may estimate the times of beginning and ending of the eclipse, respectively, within a minute or so, for any location on the chart. The time of greatest eclipse will be approximately, but not exactly, halfway between the times of beginning and ending.

The large-scale map on page 12 gives the track in the United States and Canada from the region where midtotality occurs at sunrise to the shore of Hudson Bay where the sun will have an altitude of 21 degrees at midtotality. Here the path will be 48 miles wide and the duration of totality on the central line will be 49 seconds. Were it accessible, this would be the favored place to observe the eclipse on this continent, but from the eastern shore of Lake Winnipeg eastward to Hudson Bay the path passes over a region of lakes and forests and swamps, with few habitations or camps, though it is crossed by airplane routes with landings on the shores of several lakes lying within the eclipse region.

Diagonal lines have been drawn at intervals across the path on the map to show the location of all places where mid-totality occurs at the time indicated *below* each line. The duration of total eclipse at the point where each diagonal line crosses the line of central eclipse is indicated *above* each line. This duration drops off to zero at the limits of the path. Anyone living near these limits will find it worthwhile to make the short trip, not exceeding 15 miles or so, into the path in the direction of the central line, to take advantage of the maximum duration of the spectacular and beautiful phenomena seen only during total eclipse. The solar corona will not be visible and none of the attendant phenomena observable if one is outside the limits of the path.

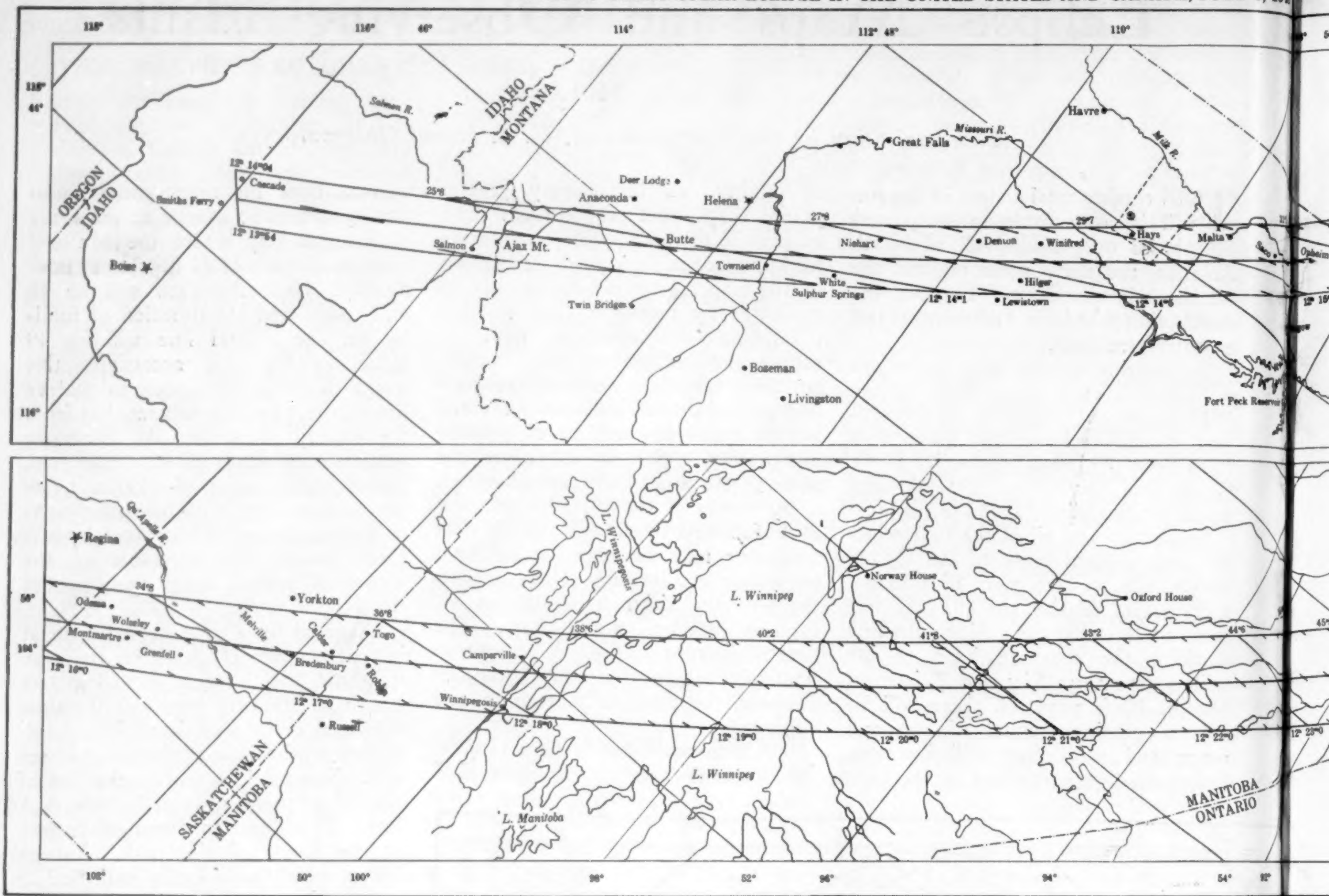
The distance of the central line from the limits is about 14 to 18 miles in the United States and 18 to 24 in Canada. The altitude of the sun in Idaho and Montana at the middle of total eclipse ranges from zero near Smiths Ferry to 8½ degrees where the path crosses the Canadian border. In Saskatchewan and Manitoba the conditions are more favorable, with the sun at an altitude of about 15 degrees on the eastern shore of Lake Winnipeg at mid-totality.

In spite of the low altitude of the sun along much of the accessible path, scientific observations of considerable importance may be made. There are certain well-recognized phenomena that usually precede the beginning and follow immediately after the ending of total eclipse. Generally, but not always, bands of alternating light



A portion of the western part of a map contained in a supplement to the 1945 "American Ephemeris," entitled "Total Eclipse of the Sun, July 9, 1945." The remainder of the chart shows the complete path of totality and gives data on the partial phases in Europe, Africa, and Asia.

PATH OF TOTAL SOLAR ECLIPSE IN THE UNITED STATES AND CANADA, JULY 9, 19



The region of the United States and Canada traversed by the umbra of the moon's shadow, from where it touche e eart to its passage across Hudson Bay. Reproduced from the eclipse supplement to the "America phem

and shade known as shadow bands appear a few minutes, at times only a few seconds, before the total phase, flitting rapidly across the ground or sides of buildings and other objects. They may or may not be seen following totality. The width of the bands, rate of motion, direction in which they are moving and in which they lie, time of appearance, and any other characteristics should be observed. It is generally believed that this is an atmospheric phenomenon, caused by surface air currents. Shadow bands were a spectacular feature of the early morning eclipse of January 24, 1925, in New York and New England and much has been written about them. Many observations of the bands were made at this eclipse and were later discussed by Dr. W. J. Humphreys, of the U. S. Weather Bureau.

During the last few minutes preceding totality the rapidly diminishing light assumes a weird, unearthly hue. The solar corona has been known to appear some seconds before the eclipse is total, especially in high altitudes. The thin solar crescent narrows to a line and disappears, or breaks up momentarily into Baily's beads if the moon's limb is particularly rough at that point.

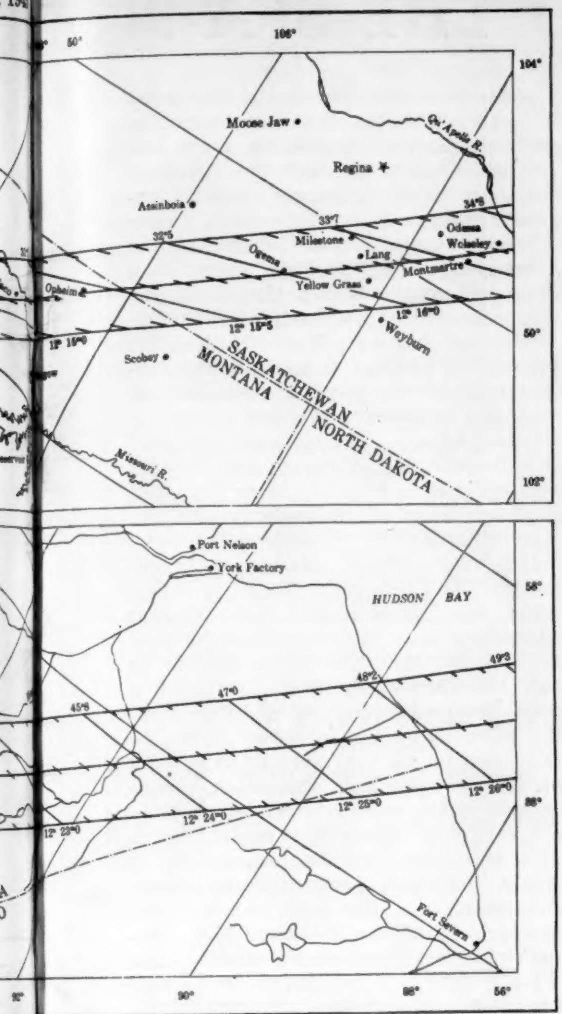
In an instant the crescent is gone. It is the time of second contact, or beginning of the total phase. At the end of totality the time of third contact is recorded as the first bead or ray of sunlight appears.

Bright solar prominences, reddish or yellow in color, may appear during totality above the edge of the lunar disk, shining as brilliant points of light through the radiance of the inner corona.

Immediately preceding or following the total eclipse the moon's shadow may be seen, approaching or receding with the terrific velocity of half a mile or more a second. To observe this, one must be at a high elevation or in a plane, with an unobstructed view toward the west before totality, and to the east after it. The velocity of the shadow increases greatly near the times of sunrise or sunset. In Montana in the eclipse of July 9th the speed with which the shadow approaches and recedes from the observer will be over three miles a second.

It is well known that the form of the solar corona changes with the 11-year sunspot cycle. As the spot minimum has but recently been passed, one may expect to see during the July eclipse a corona with long equatorial streamers and short, bushy polar rays.

Although totality will last only between 23 and 30 seconds in the United States and the sun will have an altitude of but 8½ degrees on the Canadian border, it is quite possible for a careful observer to make observations of value. If one knows his geographical position accurately with respect to well-known positions on a map, and has a timepiece, preferably a stop watch, that can be compared with time signals shortly before and after the eclipse, he may record the time of beginning, and possibly the



...e earth in Idaho at sunrise ...phemeris."

ending, of the total phase to the nearest second for comparison with the predicted times for the same position. Totality begins with the final disappearance of the thin solar crescent, if there are no Baily's beads. If beads are visible, totality may begin before the disappearance of the *last* bead. Any unusually deep lunar depression may cause a single bead to remain visible an exceptionally long time and give an erroneous value for the time of beginning of totality. Records of these times of second and third contact, if carefully made by a number of independent observers, are useful in checking the accuracy of the astronomical tables used in the calculation of eclipses.

It is also of value to know the exact position of the limits of the path, which can be found from observations made at time of greatest eclipse by those located close to the predicted positions of the limits. If one is outside the path the solar corona will not be seen. In the eclipse of January 24, 1925, the southern limit of the path crossed Central Park in New York City and its position was determined very accurately by comparing observations made by a number of people in the vicinity.

If one has a small telescope with a camera attachment, with camera lens and telescope eyepiece removed, good records of Baily's beads, the solar corona, and the prominences, may be obtained with color film.

At Huanchaco, Peru, at the time of the eclipse of June 8, 1937, the sun had an altitude of only nine degrees at mid-totality. There were many excellent photographs of the corona taken there by several expeditions and the times of the contacts were all successfully recorded. The writer obtained photographs of the eclipsed sun on Kodachrome film. The solar image was 3/8 of an inch in diameter and could be enlarged several times. These photographs were taken with a 2-inch telescope with Leica camera attachment and the eyepiece removed.

A view of the partially eclipsed sun setting in the Pacific was also obtained on Kodachrome film; so far as is known this is the only photograph of such a phenomenon. It would be of unusual general interest, even were the scientific value small, to obtain a photograph in color of the totally eclipsed sun rising in Idaho on July 9th.

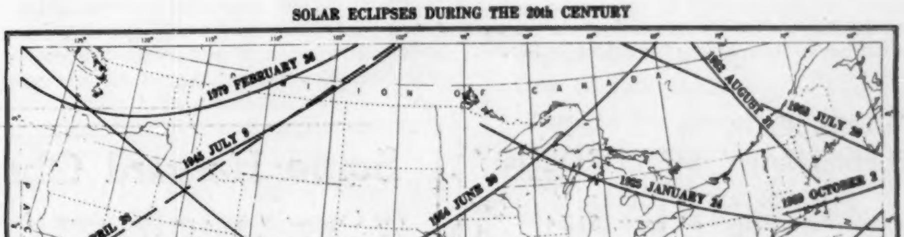
If observations of this eclipse are made at altitudes of several thousand feet, especially near the beginning of the path or from airplanes, care should be taken to apply the corrections to the position of the central line which are given on page 32 in the supplement to the 1945 *American Ephemeris* on the subject of this eclipse.* At an elevation of 10,000 feet or more, anyone observing the eclipse from a plane may get entirely outside of the path if this correction is not made.

It is advisable to choose a position close to the central line in order to have the benefit of the longest possible duration. In wooded or mountainous regions, take special care to find a site with an unobstructed view of the northeastern horizon at the time of total eclipse. One should observe the position of the sun at the time of eclipse on several days before July 9th to make certain that trees or other objects near the horizon will not obstruct the view on the eclipse morning. This will be particularly necessary in mountainous country near the beginning of the path in Idaho and Montana or on the wooded shores of lakes in Canada.

Aside from the value of the scientific observations that may be made at the time, a total eclipse of the sun is a rare and beautiful celestial phenomenon which everyone fortunate enough to be located in the path should make an effort to observe. No other total solar eclipse will be visible in this country before that of June 30, 1954, which will begin at sunrise in the Midwest and pass northward into Canada under slightly more favorable conditions.

*This booklet supplement, entitled *Total Eclipse of the Sun, July 9, 1945*, containing maps and complete data on the partial and total phases, may be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; 15 cents (do not send stamps) should accompany your order.—Ed.

SOLAR ECLIPSES DURING THE 20th CENTURY



The paths of total eclipses which cross the United States during the 20th century.

BOOKS AND THE SKY

TELESCOPES AND ACCESSORIES

George Z. Dimitroff and **James G. Baker.** The Blakiston Company, Philadelphia, 1945. 309 pages. $2.50.

ANOTHER member of the robust family of Harvard books on astronomy has seen the light; it sheds much light, too, for many professional astronomers will snatch eagerly at this chance to learn what their instruments can and cannot be expected to do. The amateur telescope maker will find here many tempting offers, for all kinds of optical systems, from several conventional refractor objectives to the most advanced of the Schmidt-type cameras, have been designed and all the numerical characteristics tabulated. The glass worker needs only to get some glass and start to work; one of the authors has told him what to head for and what he will have if he gets there.

A little of the history and most of the fundamental notions about "Light as a Tool" are given in Chapter 1; then the eye, its characteristics and deficiencies, introduce Chapter 2, "Visual Telescopes." Here as elsewhere through the book the reader will find footnotes suggesting experiments to demonstrate important effects and phenomena which in advanced optical treatises are so tangled up with mathematical formulae that they appear to have no observable real meaning. There is scarcely a score of equations in this whole book; most of them are merely definitions.

Refractors and reflectors of the conventional types are also described in this second chapter; two appendices list refractors of aperture 15 inches and upward and reflectors of aperture 30 inches and upward. The subject of eyepieces and their particular applications to various types of objectives is followed by comparisons of lens and mirror objectives. Here we find some superstitions upset; advocates of reflecting telescopes will be happy for the authoritative support for their contentions, but they must remember that the discussion concerns **perfect** objectives. Resolving power and diffraction patterns close the chapter, but there is an extremely valuable appendix that portrays three dozen stellar diffraction patterns, as related to the apertures which produce them, and these will provide both professionals and amateurs with much food for thought.

"Storing Light — The Photographic Process" is Chapter 3; in it are the fundamentals of the physical and chemical processes involved and their effects on the final images. The beginner will read this chapter with pleasure and the expert will not be bored as he reviews this good summary of the important things.

In Chapter 4, "Photographic Telescopes," the authors take hold with firm hands. They define and illustrate everything they mention and they mention everything that can contribute to good or bad photographs—except failure to pull the dark-slide at the start of a three-hour exposure in mid-February! We learn that coma in reflectors can be alleviated by zero-correctors but only by producing spherical aberration, hence several large reflectors made by Zeiss are very fast but useless except on the axis, unless severely diaphragmed to increase the ratio between focal length and aperture. The best non-technical comparisons of the Schwarzschild, Couder, Ritchey-Chrétien, Schmidt, and Wright cameras are found here, with complete specifications for manufacture of optimum examples of each. Photographic refractors from the old astrographic to the Ross types are compared and calculated ready for work in the shop. The chapter closes with a realistic discussion of limiting magnitudes, including a very handy table copied from a paper by Whipple and Rubenstein.

"Sifting Light—Spectroscopy" is the title of Chapter 5; again the range is from the most elementary to the most

modern—from the objective prism to the image-slicer and very efficient nebular spectrographs that employ no objectives. Chapter 6 is "Measuring Light"; included in this section are the methods of working directly at the telescope as well as those employed to wrest magnitude values from photographs already taken.

In Chapter 7, "Instruments for Solar Research," the general instruments are introduced, then the specific installations at the McMath-Hulbert Observatory of the University of Michigan are described in great detail, as to equipment and methods and results. The concluding sections deal with the coronagraph and the monochromator.

The amateur may be misled by the title of Chapter 8, "Building a Telescope," for there is here no repetition of instructions that are given in other books. This chapter deals rather with the large professional telescope—the lens or mirror, the tube, the mounting, driving clock, shelter—and its use, and here the amateur will be sure to find answers to many questions that he has always wanted to ask someone.

The seven appendices and a good index complete the book, and a fine one it is. The many fresh illustrations are very welcome, as is also the realistic approach to the problems of instrument design and, quite important, to the use of the completed instrument. The authors are experienced in both design and use of telescopes of all sizes and have stripped away the interesting theoretical in favor of the profitably practical. They have performed a real service to all lovers of astronomy, but particularly to the observers who want to get the most out of the instruments they have.

ROY K. MARSHALL
Fels Planetarium

NEW BOOKS RECEIVED

KEPLER AND THE JESUITS, *M. W. Burke-Gaffney*, 1944, *Bruce*. 138 pages. $2.00.

A biography of Kepler, stressing particularly his scientific work, with numerous quotations from his correspondence, and his relations with contemporary Jesuit astronomers and mathematicians.

PRACTICAL MARINE NAVIGATION, *James A. Stowell*, 1945, *Addison-Wesley*. 133 pages and index. $2.50.

A book presenting in compact form with numerous examples the basic mathematics of marine navigation. Trigonometric and logarithmic methods, such as cosine-haversine solution of the astronomical triangle, are used throughout, and short-cut procedures are purposely omitted.

THE COMET OF 1577: Its Place in the History of Astronomy, *C. Doris Hellman*, 1944, *Columbia*. 488 pages. $6.00.

The history of cometary theory to 1577, and a thorough discussion of this comet and the effect which study of it had upon the history of astronomy. Fully annotated.

DECORATION VERSUS SCIENTIFIC REPRESENTATION

(Continued from page 2)

who gaze with puzzled rapture at the stars twinkling overhead in the big station. Nor will our many navigation-minded service personnel be led astray by a star map which tells them to go east when they should be going west.

The reputed cost of doing the ceiling over was $150,000, while another $40,000 would have been needed properly to relocate the lights for the stars. Although this latter figure seems in reasonable proportion to the total high cost, it prevented the correction of an error which is now refreshed and perpetuated —a symbol of current general ignorance of simple facts concerning the stars.

DORRIT HOFFLEIT

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern war time.

A Strange Saturnian Illusion

Among the many singular phenomena of that most singular of planets, Saturn, is one that appears to be fairly common and which, for strangeness, deserves to be ranked with the classical "square-shouldered aspect." But the appearance of which I write is confined to the rings.

An observer armed with even a small telescope, providing that it is a very good one, cannot fail to notice that the rings differ considerably in magnitude. The outermost, ring A, is not as bright as B, the second and most luminous of the system; while C, the innermost or crape ring, is very dark. But it may not be noticed at once that the rings differ also in color. A has a decided orange tint; B is uniformly a golden yellow; while C is of a dusky hue generally tinged a slaty blue. And now for certain remarkable variations in these colors.

On the morning of October 9, 1942, at 12:06 a.m. E.S.T., with good definition, I was using a 3-inch refractor on Saturn, when I observed ring A to be **differently colored on different sides of the ball.** On the following side it was a clear slate-blue while on the preceding side it was ruddy. The blue tinge even extended to ring B which, however, was not so affected by the ruddy tint on the preceding side. Something of the sort had been seen before, but never so clearly.

On October 20th that year, at 12:10 a.m. E.S.T., definition good, the bi-colored aspect of ring A was seen again, but in reverse. On this occasion the ring was blue on the preceding side and a pale orange on the following.

On November 1, 1942, at 10:55 p.m. E.S.T., with inferior definition, the two colors were seen again; but now they had been restored to the position of the morning of October 9th. The interchange of colors at first suggested that the phenomenon might be an objective reality, changing place in accordance with the revolution of the ring. This theory was further enhanced by the fact that my wife saw the two-color aspect of A, without having had previous knowledge of it, and correctly placed the colors with respect to the ball.

Cursory investigation revealed that the phenomenon was nothing new. Webb noted it in his admirable **Celestial Objects**, writing that "the general slaty hue [of the ring] has at times been seen different on two sides of the planet, reddish and bluish." He also cited Dawes and Lassell as having "repeatedly" seen the interchange of tints between the preceding and following sides, and suggested that revolution of the ring might account for the shifting of the colors. Webb, therefore, probably regarded the phenomenon as objective; but he was writing of the crape ring. It seems clear, therefore, that this singular appearance is common at one time or another to all three rings.

In order to test whether the appearance was an illusion or a reality, I attempted to correlate the interchange of tints in ring A with the rotation period of the ring; but no correspondence was found. The appearance depended to some degree upon the power used. On the night of November 11, 1944, when the bi-colored aspect was well seen with low power, I found that with powers of 75x and 115x the ring appeared to be normally orange-yellow on both sides of the ball.

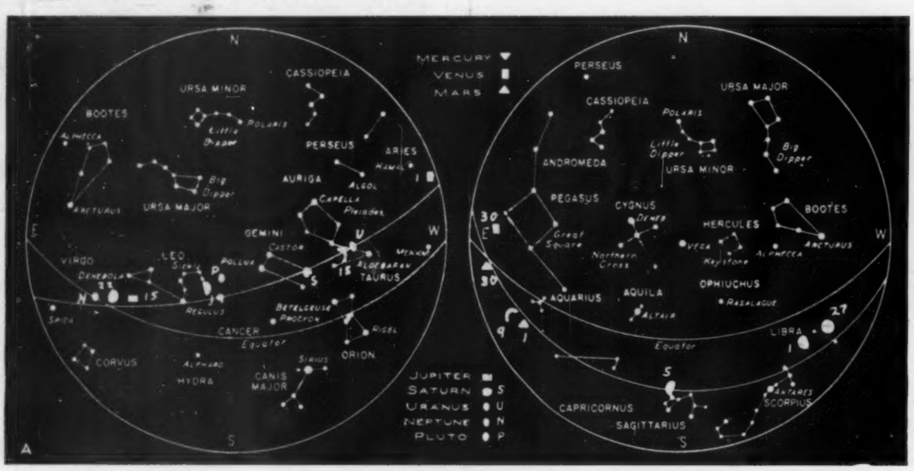
Moreover, it was noticed that the colors never blended into one another, but were always sharply delineated by the limbs of the ball. If the ring were blue on the following side, the blue color could be traced up to the limb, but there it stopped. The same was true of the red side. The two limbs formed an impassable barrier, and this was true no matter on which side of the ball the respective colors lay.

All of this, of course, strongly implied that the appearance was simply an illusion, however created in the first place. A recent observation removed all doubt.

On the evening of January 24, 1945, at 6:10 p.m. E.S.T., with variable definition owing to high northwest winds, ring A was seen to be ruddy on the following side and blue on the preceding. After observing steadily for a few minutes my eye became fatigued and began to itch. Time out was taken to rub the offending orb, and when the eyepiece was again consulted the colors were again seen, **but in reverse.** It was then found that by sudden changes of focus, or by interchange of powers, the colors could be made to shift back and forth spasmodically on either side of the ball. Indeed, by merely staring at the ring steadily for a few minutes the colors would shift under one's eye, so to speak.

It seems clear, therefore, that this remarkable illusion depends upon the

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 8:30 p.m. on the 7th and for 7:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury may be seen in the evening sky for the first few days of the month. During April it passes the sun, and dawn will prevent good observation of it in the morning sky.

Venus is also in the evening sky after sunset at the first of the month, and passes the sun on the 15th, to enter the morning sky, where it will be easily observable by the end of the month.

Mars, although 2.5 hours ahead of the sun in right ascension, has a southerly declination which will make it visible only as a faint object in the morning twilight.

Jupiter is in Leo, well placed for observation through the month.

Saturn is in Gemini; its magnitude is +0.3. On the 2nd, it will be 18′ north of Mu Geminorum, magnitude 3.2.

Uranus is in Taurus. See diagram in the January issue.

Neptune is in Virgo. See diagram in the January issue.

PHASES OF THE MOON

Last quarter	April 5, 3:18 p.m.
New moon	April 12, 8:29 a.m.
First quarter	April 19, 3:46 a.m.
Full moon	April 27, 6:33 a.m.

state of the eye—at least with respect to which side of the ball the colors will be found. It does not depend upon definition, moonlight, or aperture (at least within moderate variation, for I have seen it with a 5-inch as well as a 3-inch). On the other hand, this does not explain the mechanism, nor why the illusion should appear at the very beginning of an observation before the eye has become fatigued, nor why it is not always seen. It is probably related in some manner to the secondary spectrum exhibited by even the best achromatic lenses, especially with large, bright objects such as planets. At any rate, it makes an interesting if somewhat disconcerting appearance and is a worthy puzzle for those who like to delve into the mysteries of optics or of the ringed Saturn.

JAMES C. BARTLETT, JR.
Chairman, Astronomical Section
American International Academy, Inc.

R CORONAE BOREALIS

Late in February, a decrease was noted in the light of the erratic variable R Coronae Borealis. D. W. Rosebrugh, of Waterbury, Conn., made the first report, which was later confirmed by C. F. Fernald, of Wilton, Me. This may be a drop to a deep minimum, a preliminary slight decrease before a real drop, or a decrease of only a magnitude or so to be followed by a return to full maximum.

At its preceding decrease of light, the star, normally of 6th magnitude, fell to a magnitude of 12.5. It took nearly a year from its original loss of brightness in October, 1942, before it regained normal maximum brightness. Although now rather poorly placed for observation, this object warrants close attention from interested amateurs.

LEON CAMPBELL
A.A.V.S.O.

THE LYRIDS

The Lyrid meteor shower is due from about the 20th to the 22nd of April, with maximum on the 21st. The quarter moon will make observing of this shower somewhat unfavorable.

VESTA'S POSITIONS

According to the **Handbook** of the British Astronomical Association, this brightest of the asteroids will reach the 6th magnitude this month. At the end of the month, it will be near Delta Virginis, as shown by the following ephemeris. It is at opposition on April 5th at 6 p.m.

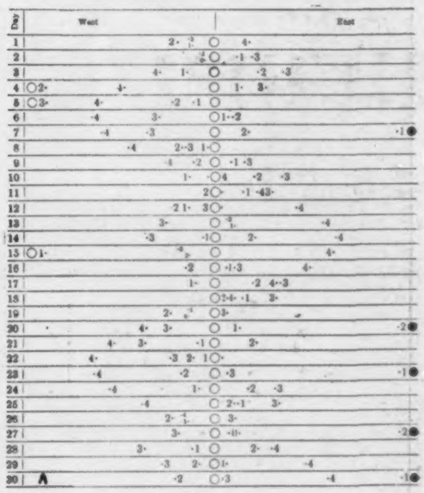
Date		*h*	*m*	°	′	*Mag.*
April	1	13	22.2	+5	9	6.2
	11	13	13.1	+6	8	6.2
	21	13	4.1	+6	49	6.2
May	1	12	56.4	+7	5	6.3
	11	12	51.0	+6	56	6.3
	21	12	48.4	+6	22	6.4
	31	12	48.7	+5	27	6.5
June	10	12	51.8	+4	15	6.6
	20	12	57.4	+2	49	6.8
	30	13	5.3	+1	13	6.9

JUPITER'S SATELLITES

On April 5th after 1:01 a.m. and on the 8th after 0:21 a.m., the principal moons will be west of Jupiter. During the evenings of the 10th and 17th, they will be on the east side. On April 30th before 9:55 p.m., the satellites will be east of Jupiter, and in numerical order outward.

On April 1st at 8:17 p.m., moon IV will reappear after transit, and at 10:07 p.m., its shadow will begin to cross the disk. The observer will have few opportunities to view configurations of this satellite during Jupiter's current appearance, and should take advantage of them. For the next few years the apparent inclination of the planet's axis of rotation will cause IV to pass above or below Jupiter's disk.

Jupiter's four bright moons have the positions shown below at 1:00 a.m. E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris and Nautical Almanac.**



OCCULTATIONS—APRIL, 1945

Local station, lat. 40° 48′.6 north, long. 4^h $55^m.8$ west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Apr. 2	6.4	73 B Scorpii	5:04.2 a.m.	57°	6:00.9 a.m.	342°
14	6.9	BD +16° 527	8:17.4 p.m.	31°		
16	6.7	BD +21° 1072	10:41.5 p.m.	135°		
17	6.9	BD +22° 1531	10:30.5 p.m.	57°		
26	5.8	80 Virginis	3:27.8 a.m.	90°	4:33.8 a.m.	323°
30	6.5	123 B Scorpii	0:36.6 a.m.	137°	1:52.2 a.m.	268°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium, 81st Street and Central Park West, New York City, and of the Buhl Planetarium, Federal and West Ohio Streets, Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *April*, "ABC'S OF ASTRONOMY."

In this production, visitors are given a rapid survey of the universe, to reveal its structure and see the many kinds of heavenly bodies that make it up. In the starry heavens we view comets glowing weirdly, the flashing meteors, the endlessly gyrating planets, the northern lights, an eclipse of the moon. The magic of the telescope then takes us out to the star clusters, the nebulae, and the unbelievably distant galaxies.

★ **THE HAYDEN PLANETARIUM** presents in *April*, THE STARS OF SPRING. (See page 6.)

In *May*, WHY THE WEATHER? Meteorology is an important science for airmen and soldiers everywhere. And watching the weather cycles makes a fascinating hobby for many people. Some of the scientific facts about weather, and some of the old weather proverbs, often based on sound principles, are topics for discussion in this month's demonstration.

★ SCHEDULE BUHL PLANETARIUM

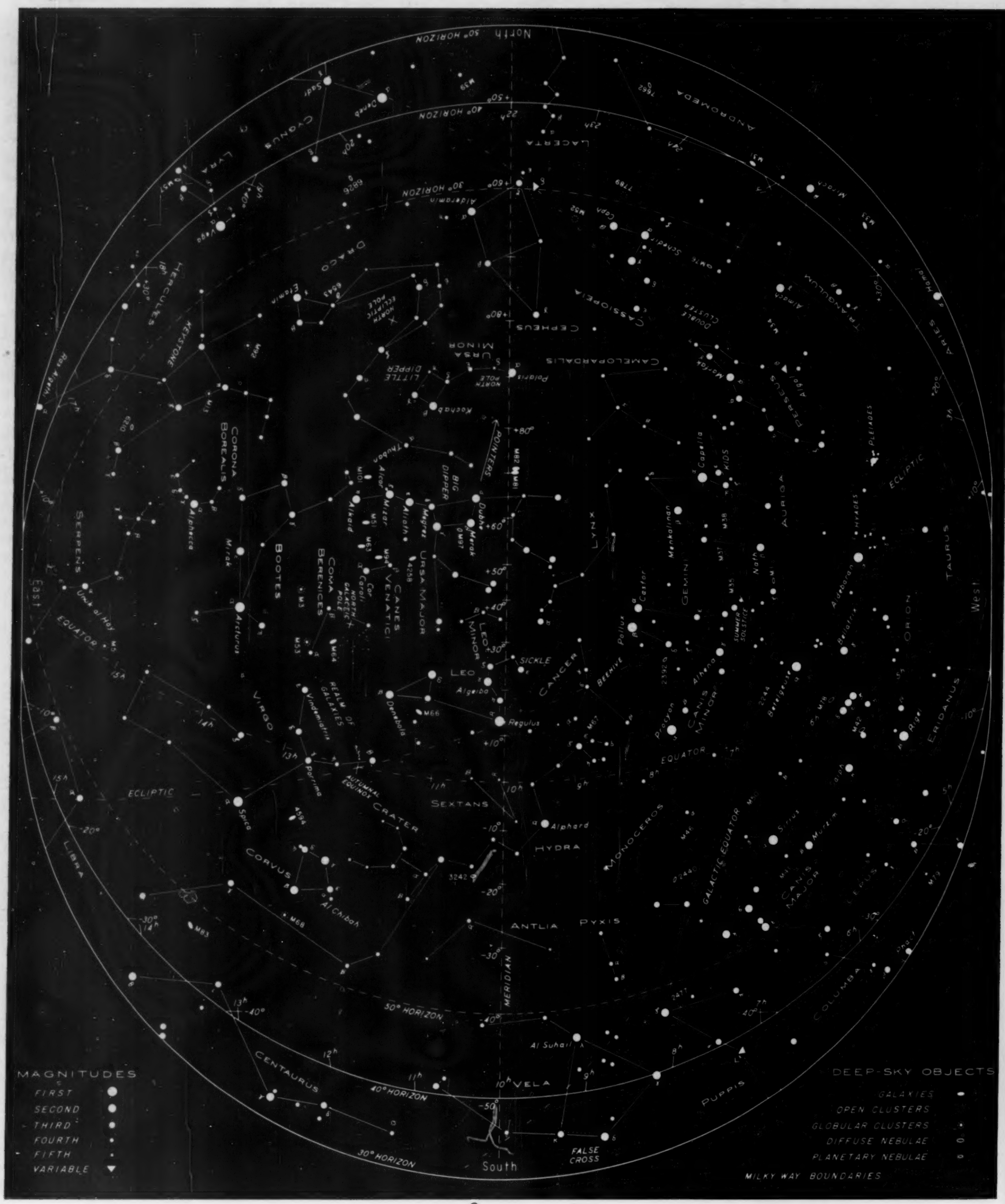
Mondays through Saturdays .... 3 and 8:30 p.m.
Sundays and Holidays .... 3, 4, and 8:30 p.m.

★ STAFF—*Director*, Arthur L. Draper: *Lecturer*, Nicholas E. Wagman: *Manager*, Frank S. McGary: *Public Relations*, John F. Landis: *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.: *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays .... 2, 3:30, and 8:30 p.m.
Saturdays .... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays .... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher: *Associate Curator*, Marian Lockwood: *Assistant Curator*, Robert R. Coles (on leave in Army Air Corps): *Scientific Assistant*, Fred Raiser: *Lecturers*, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.



DEEP-SKY WONDERS

AMONG marvels for observation in the April skies are the objects listed here, some of which are not shown on the chart above. The informal descriptions are for common telescopes. Norton designations are in parentheses.

Canes Venatici. NGC 4485 and 4490 (198^1), 12^h $28^m.2$, $+41°$ $58'$; galaxies. In amateur telescopes they resemble a cocoon between a roundish galaxy and a star. NGC 4631 (42^5), 12^h $39^m.8$, $+32°$ $49'$; handsome edge-on galaxy. M94, 12^h $48^m.6$, $+41°$ $23'$; oval galaxy, three million light-years distant.

Taurus. NGC 1746 (21^7), 4^h $57^m.6$, $+23°$ $40'$; cluster of 60 stars.

Puppis. NGC 2422 (38^8), 7^h 32^m, $-14°$ $16'$; cluster of 50 stars.

L. S. COPELAND

CHART CORRECTION: Antlia is 10° too far north; NGC 6543, in Draco, should be at 17^h $58^m.6$, $+66°$ $38'$.

STARS FOR APRIL

from latitudes 30° to 50° north, at 10 p.m. and 9 p.m., war time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

EVENING STARS FOR SOUTHERN OBSERVERS

THIS is the fifth map in the series of star charts for use by observers in the Southern Hemisphere, and matching the northern maps. It is prepared for a basic latitude of 30° south, but may be used conveniently 20 degrees on either side of that parallel. These southern charts appear in alternate months, but always two or three months in advance, to allow time for transmission to observers in any part of the world. When 12 charts have been produced, and if interest warrants, a special edition of **Sky and Telescope** may be published each month carrying observing material for Southern Hemisphere observers. This chart is for use in latitudes 20° to 40° south on June 7th at 11 p.m., June 23rd at 10 p.m., July 7th and 23rd at 9 p.m. and 8 p.m., respectively. Times for other days vary similarly: four minutes earlier per day. These are local mean times which must be corrected for standard time and war time differences. The 30° horizon is a solid circle; the other horizons are circles, too, those for 20° and 40° south being dashed in part. When facing south, hold "South" at the bottom, and similarly for other directions. Observers in the tropics may find north circumpolar stars on any of our northern star charts.

GLEANINGS FOR A.T.M.s

MAKING YOUR OWN TELESCOPE

From Start to Finish—6

By ALLYN J. THOMPSON

VII—THE DIAGONAL

How Large? The diagonal is a very vital part of the telescope, and in order to perform its function well, it must be of the proper size, and it must be flat enough. The size can be arrived at by formula, but there is the related question of illumination of the field which enters into the discussion, and which should be understood, so we had better take out the drawing board and expose the workings of the telescope graphically. Here the amateur should make his own drawing, to ½ scale at least, based on his exact focal length. Fig. 21 is a diagrammatic solution of the problem for a 6-inch f/8 telescope.

Draw MA to represent the axis of the mirror, and M'M", the mirror's surface. At the scale distance of 48" from M, draw FP to represent the focal plane. If a strip of ground glass were laid across this plane, an evenly illuminated image of the distant landscape would be seen on it, extending clear across. The same width of image might be produced at fp (if the opening at the side of the tube were wide enough) by the introduction of the diagonal, but the same brightness would be found only near the center of this new image, which would become fainter toward the edges. The area of greatest brilliance will depend on the size of the diagonal, and it is only necessary to illuminate as much of the field as can be received into the eyepiece. Good Ramsden oculars of low power, 1¼" to 1½" focal length, have a field lens of 1" clear aperture, and that is the linear width of the field (VV') taken in by that ocular. Now draw MV and MV'. Angle VMV' is the angular size of the **real** field of view which, based on a radius equal to the focal length, is equal to 1 1/6° of arc. Two moons side by side would fit easily into this field. (The image of the moon at the focus of a 6-inch f/8 is about 2/5" in diameter.) Or two stars, separated by 1° 10' of arc, would just fit into the field, and would be situated at V and V', respectively.

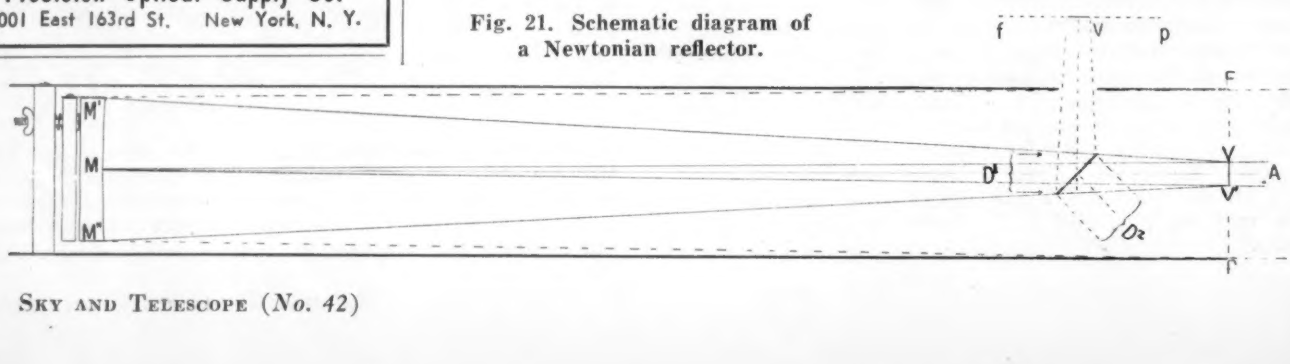
Draw M'V and M"V', forming the figure of a truncated cone, in which are confined all of the rays from the square degree of sky which go to make up the image VV'. Wherever we place our diagonal, it is apparent that it ought to take in the full width of the trapezoid, and the nearer it is to the focal plane the smaller it can be, so let us see how near we can place it. From a constructional standpoint it will be found most convenient to have the deflected focal plane lie about 3" outside the tube, and this plus the radius of the tube is the distance inside of focus that we place the diagonal.

We should like to have the tube no larger than the mirror, if possible, but as can be seen from the angle VMV', the field of view is an expanding one, and at the focal plane it is ½" larger all around than the mirror. So the tube may not be less than 7" in diameter. This places the diagonal 6½" inside of focus, and there we draw it, at an angle of 45° to the mirror's axis, and measure its minor and major dimensions, D^1 and D^2. Its shape is an ellipse, with the minor axis 1.7", and the major axis 2.4" (a ratio of 1 to 1.4). It will obstruct a little more than eight per cent of the light coming to the mirror. A rectangular shape of the same dimensions (by far the easiest to make) will obstruct a trifle more than 10 per cent of the light.

The formula referred to in the first paragraph is $D^1 = c(M - f)/F + F$; $D^2 = D^1 \times 1.4$, where f is the width VV', c is the distance of the diagonal inside the focal plane, F is the focal length, and M the diameter of the mirror.

What is the effect of using a smaller diagonal? Briefly, the result is a loss of illumination in the outer edges of the field of the low-power eyepiece. Take, for example, the off-axis star whose image is formed at V. It is apparent that if the diagonal fails to take in the ray M'V, there will not be full illumination in that image, and the star will appear fainter than one of equal magnitude lying nearer to the center of the field. In other words, the outlying stars would not get the benefit of the full aperture of the mirror when using the low-power eyepiece. The field lens of a ½" ocular is about ⅜" in diameter and takes in a correspondingly smaller

Fig. 21. Schematic diagram of a Newtonian reflector.



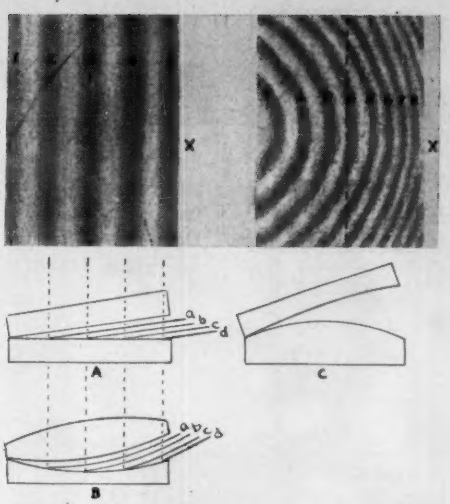
field, so unless the diagonal were tiny, high-power oculars would not be affected. It may be desirable, however, to give consideration to yet another factor. Star images and planetary detail suffer from diffraction effects caused by the obstructing diagonal. This becomes noticeable when the obstruction exceeds five or six per cent of the area of the mirror. But we must have the diagonal, and without becoming too deeply involved in optics, it may be said that the only way to reduce its size successfully is to contrive to bring it closer to the focal plane. And the only way to do this is to use a mirror of longer focal length, or restrict it, primarily, to the use of medium- and high-power eyepieces.

Since ours is to be an all-purpose telescope, within its limits, we shall deal with the full-sized diagonal. But if given the choice between it and a somewhat smaller one of elliptical shape, say 1½" on the minor axis and obstructing little more than six per cent of the light, I will admit to a preference for the latter.

How Flat? We have taken great pains to produce a curve of remarkable precision on our mirror. We should be equally concerned that nothing shall happen to alter the course of the rays from the mirror, and interfere with the formation of a perfect image. While annealed plate glass appears perfectly flat, we shall seldom find one among several pieces, say 2" square, that is flat to better than .0001". Placed an inch or so inside of focus, a diagonal of that quality could do no harm, but at our distance of 6½" it must be optically plane to within one wave length of light, about 1/50,000 part of an inch.

A prism is sometimes used, instead of the aluminized plane mirror, but it has three surfaces, each of which must be flat to a quarter of a wave length, and the cost of such a prism is considerable. In reflective ability, prism and diagonal are about equal. The aluminized flat reflects about 90 per cent of the incident light; the prism is totally reflecting; but in the prism about four per cent is lost in reflection from each of the square faces, and a negligible amount is lost in absorption.

Plane surfaces are tested for flatness by placing two polished surfaces together, and studying the interference bands that appear between them under monochromatic light. The surfaces must be cleaned of all grease and dust or the bands may not be seen. The explanation of these bands, or fringes, is fully covered in textbooks on physics, and will not be discussed here. Suffice it to say that they should be interpreted just as are the contour lines on a map, where the terrain along any given line is all of the same elevation. For example, in Fig. 22, anywhere along fringe 2 is a half wave length above or below fringe 1; fringe 3 is a half wave length



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above or below fringe 2; and so on, depending on whether the surfaces are convex or concave to each other, or, if they are flat, on the direction of the wedge opening. In Fig. 22 left, the fringes are straight, indicating that the surfaces are flat, and the number of fringes seen depends on the size of the wedge of air between them. By pressing at X, we narrow this wedge, and the fringes spread out, becoming fewer until, when the wedge is closed, only one fringe is present, spread across the whole surface. Note that spherical surfaces which fit each other perfectly (Fig. 22B), as, for example, the crown and flint glass components of an achromatic lens, will show the same pattern of straight fringes.

By laying a straightedge along the fringes and counting their number intersected by it, we can tell the number of wave lengths of convexity or concavity of the surfaces. Thus in Fig. 22 right, they are three fringes, or 1½ wave lengths, convex or concave. By appropriate pressing, at X in this case, the bull's-eye or center of the fringe system can be brought into view, and we have the pattern shown in Fig. 23c. Here we count three rings, which also tells us that the surfaces are 1½ wave lengths off. The center of the bull's-eye is the high point or low point, depending on whether the pieces are concave or convex to each other.

To determine which is the case, lower the eye or press at the center. If the fringes spread out, the surfaces are convex; if the fringes close in, they are concave.

In commercial optics, surfaces are tested against a master flat of high precision, so the exact condition of the specimen is immediately known. We have no master flat, but we can, by the introduction of a third piece and a little

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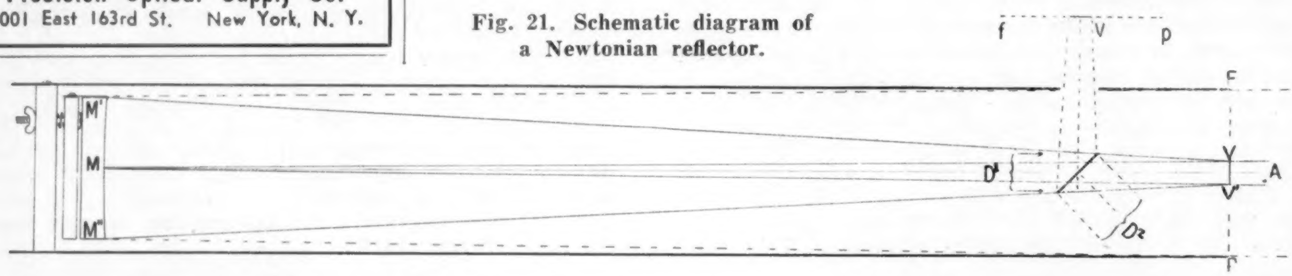

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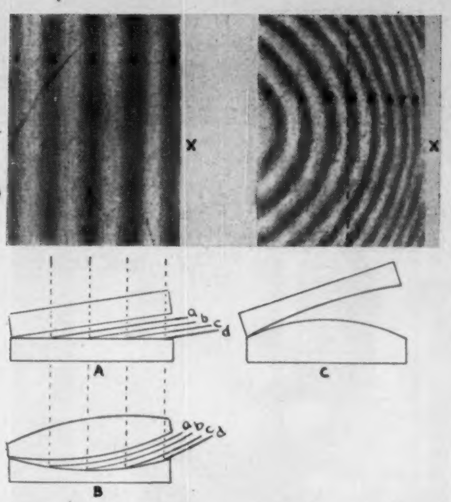

Fig. 22. Testing for flatness, using interference of light waves. It is helpful, in interpreting the bands, to regard the imaginary surfaces as shown by the dotted lines, a, b, c, and d, as being parallel to the upper surface. The separation between these imaginary surfaces is always equal to one half a wave length of the light used.

above or below fringe 2; and so on, depending on whether the surfaces are convex or concave to each other, or, if they are flat, on the direction of the wedge opening. In Fig. 22 left, the fringes are straight, indicating that the surfaces are flat, and the number of fringes seen depends on the size of the wedge of air between them. By pressing at X, we narrow this wedge, and the fringes spread out, becoming fewer until, when the wedge is closed, only one fringe is present, spread across the whole surface. Note that spherical surfaces which fit each other perfectly (Fig. 22B), as, for example, the crown and flint glass components of an achromatic lens, will show the same pattern of straight fringes.

By laying a straightedge along the fringes and counting their number intersected by it, we can tell the number of wave lengths of convexity or concavity of the surfaces. Thus in Fig. 22 right, they are three fringes, or 1½ wave lengths, convex or concave. By appropriate pressing, at X in this case, the bull's-eye or center of the fringe system can be brought into view, and we have the pattern shown in Fig. 23c. Here we count three rings, which also tells us that the surfaces are 1½ wave lengths off. The center of the bull's-eye is the high point or low point, depending on whether the pieces are concave or convex to each other.

To determine which is the case, lower the eye or press at the center. If the fringes spread out, the surfaces are convex; if the fringes close in, they are concave.

In commercial optics, surfaces are tested against a master flat of high precision, so the exact condition of the specimen is immediately known. We have no master flat, but we can, by the introduction of a third piece and a little

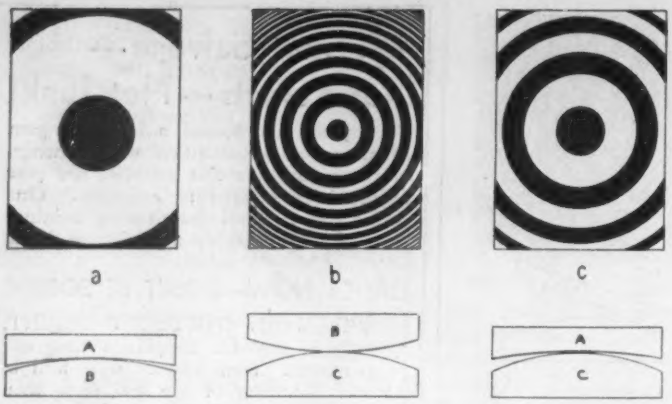

Fig. 23. Fringe patterns from various combinations of the pieces of glass tested.

elementary algebra, determine the status of each with all necessary accuracy. We shall take for an example three samples of Crystalex plate glass which I recently tested. For identification, we mark them A, B, and C.

Placing A on B, we get the fringe pattern in Fig. 23a, which shows one fringe convex. B on C gives the pattern at b, eight fringes convex. A on C gives the pattern at c, three fringes convex. Let us call convex plus, and concave minus. Now we have three simultaneous equations: $A + B = 1$

$$B + C = 8$$
$$A + C = 3$$

Removing B from the first two equations by subtraction gives us $A - C = -7$. By combining this equation with the third and solving for A we get, $A = -2$. Substituting this value for A in the first equation we find that $B = +3$. Substituting for B in the second equation, we get $C = +5$. We see, therefore, that:

A is 2 fringes (1 wave length) concave,
B is 3 fringes (1½ " ") convex,
C is 5 fringes (2½ " ") convex.

The cross sections shown in Fig. 23 are an exaggerated concept of how these surfaces fit each other.

Making a Diagonal. If the reader should be fortunate enough to find similarly good specimens, he has his diagonal without further effort. If his mirror is overcorrected, he should choose piece B; if undercorrected, piece A. But let us suppose that it is desired to correct C, using B to test with.

We cut up pieces of glass of the same

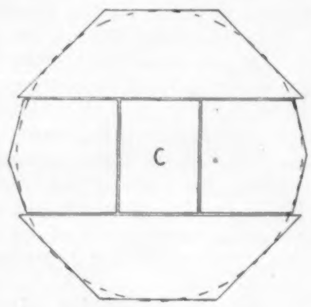

Fig. 24. Diagonal, C, and protective pieces of glass blocked up on a tool for grinding and polishing.

thickness (and this should be ⅜" or ½", rather than the ¼" usually found in plate glass) so that they can be cemented with paraffin to the flat side of our 6" glass tool (on which the mirror was ground) with the diagonal-to-be in the center (Fig. 24). First grind the flat side of the tool, and one side of each of the several pieces with #120 or #220 Carbo. This will give a roughened surface on which the paraffin can get a bite. Then lay the pieces on the tool and place them all in a pan of water, with two or three small wooden blocks between the tool and the bottom of the pan. Bring the water to a slow boil to insure thorough even heating of the glass. Don't have any glass in direct contact with the bottom of the pan or it will crack. In the meantime melt up some paraffin in a can. When ready, remove and dry the glass pieces. Pour a film of melted paraffin over the flat side of the tool, and place the diagonal and surrounding pieces on it after the pattern of Fig. 24. Allow them to seat themselves without, however, touching each other. When the whole has cooled, pour melted paraffin into the spaces between the pieces, filling them to the level of the surface. Cemented in this way, no strains are likely to have been introduced in the diagonal, as might be the case if pitch were used as the holding medium. The surfaces will hardly be all in the same plane, but the slight differences can be corrected by fine grinding with #400 Carbo until they are brought to the same level. Grind on a large piece of scrap plate glass, about 8" square, and the thicker the better. Distribute the grinding evenly all over and use short strokes. Rotate the "flat" and walk around the barrel as with the mirror. Finish up with #304 emery, at which time a straightedge laid across any diameter should be absolutely light-tight.

The polishing lap must be made on another 6" glass disk or thick iron plate, following the technique described in Chapter IV. The molded lap, made with the horizontal rows of facets uniformly spaced, is unexcelled for figuring optical flats.

In either case a third disk, of glass, must be used for forming the lap, as the heat from the pitch would melt the paraffin in the built-up flat.

Before commencing the polishing, scrape away the paraffin filler between the pieces to a depth of about 1/16". After a half hour of polishing, test the diagonal for interference fringes, to see what the effect of the grinding was. Continue polishing, using one-third strokes, until the diagonal is completely polished out. The condition of the surrounding pieces does not matter. Their purpose is to protect the edges of the diagonal, which would otherwise be hopelessly turned. Cold-press frequently for contact, but with little weight. On account of the broken-up surface of the plane mirror, the onion sacking mentioned in Chapter V should be used in cold-pressing for contact.

The strokes used in figuring will depend on the amount of convexity or concavity present. The same reasoning must be applied as in dealing with the various shapes on the mirror. If greatly convex, lengthen the strokes; if concave, work upside down. Allow plenty of time for the glass to cool before testing—an hour before the final test. Stop when test piece B shows anywhere between one and five fringes convex. In the first instance, the diagonal would be two fringes concave; in the second, two fringes convex. If it were flat, the test would show three fringes convex.

To free the diagonal from the paraffin, lay the whole assembly on a board, and place it in an open oven for a few minutes.

(To be continued. Next month—the tube and its collimation.)

SKY-GAZERS EXCHANGE